(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 363 530 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88309448.4

(22) Date of filing: 10.10.88

(43) Date of publication of application: 18.04.90 Bulletin 90/16

(84) Designated Contracting States: DE ES IT

(51) Int. Cl.5: A62B 18/00 , A62B 7/00

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(54) Respirator.

(57) A respirator comprising a cowl (1) impervious to NBC agents shapes to enclose a wearer's head and neck, the cowl (1) having a transparent viewing window (4) therein and an inlet (14) for admitting a breathable mixture to the interior of the cowl (1). The inlet (14) is constructed to direct all or the major proportion of the supplied breathable mixture to the interior of the cowl (1) so that it flows past the window (4). A face mask (7) is fitted inside the cowl (1) and shaped to fit over the wearer's nose and mouth and make a seal with his face when held in position thereon. The mask (7) has at least one normally closed inhalatory valve therein (17), and an outlet (18) therefrom leading to the exterior of the cowl (1) incorporating one or more normally closed expiratory valves (20, 21) therein so that, in use, at least the major proportion of the breathable mixture is supplied to the interior of the cowl (1) past the interior of the window (4) to de-mist it, the breathable mixture in the cowl (1) then being admitted to the interior of the face mask (7) through the or each inhalatory valve (17) only on inhalation by the wearer and exhausted therefrom through the or each expiratory valve (20, 21) only on exhalation by the wearer, the exhalation by the wearer opening the or each normally closed expiratory valve (20, 21) in the outlet (18).

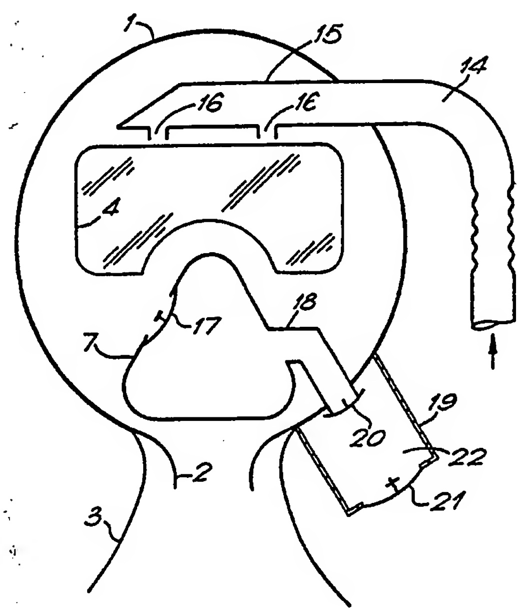

FIG.1.

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to permit flow of the breathable mixture to the interior of the cowl, but being operable to close on sensing a substantial drop in the external pressure or increase in delivery pressure, the hood inlet valve including a sealing member which seals against a seat, said sealing member having a calibrated hole therein to permit limited flow therethrough, when the valve is closed, to supply the window in the cowl with a limited flow of said breathable mixture sufficient for demisting purposes. The hood inlet valve can be of any convenient type such as an aneroid valve or a diaphragm valve.

In a preferred embodiment, the expiratory valve upstream of the deadspace is a compensated valve which comprises a sealing member which is normally biassed by means to seal against a seat, said sealing member also being connected to a diaphragm and movable thereby into sealing engagement with the seat, the diaphragm forming part of a sealed chamber, the interior of which is connected by a by-pass duct to said smaller bore inlet duct, whereby in use, on inhalation, the secondary inlet valve opens to admit said breathable mixture to the interior of the mask, there being no pressure differential across the expiratory valve due to the bypass duct connecting the interior of the sealed chamber with the secondary inlet duct so the expiratory valve remains closed under the action of its biassing means, said secondary inlet valve being closed on exhalation and the increase in pressure in the face mask generated thereby overcoming the action of the expiratory valve biassing means and causing it to open.

In order to cope with sudden depressurisation of the cabin which would cause the cowl to inflate rapidly, the cowl preferably includes a separate relief valve operable to vent the cowl to atmosphere should a substantial pressure differential arise between the interior and the exterior of the cowl.

The cowl can additionally be provided with means whereby the interior of the cowl can be placed in communication with its exterior at normal atmospheric pressure. Such means are particularly useful in cases where the pilot lands in water because he then needs to breathe normally. He can do this in many ways, for instance by puncturing the cowl material or manually releasing a valve. Alternatively, the cowl could be provided with a water sensitive valve which opens when a part thereof comes into contact with water.

Optionally, the mask could also include a rip-out face section in accordance with our patent application No. 8329024.

Two preferred embodiments of a respirator of the invention will now be described, by way of example only with reference to the accompanying drawings in which:-

Figure 1 is a schematic drawing of one form of respirator suitable for use at altitudes up to 40,000 feet.

Figure 2 is a schematic drawing of the respirator of Figure 1 modified for use at altitudes above 40,000 feet, and

Figure 3 is a schematic side view of the respirator of Figure 1 as worn by a pilot under his flying helmet.

Referring to the drawings, there is shown in Figures 1 and 3 a respirator for use at altitutdes up to 40,000 feet comprising a thin NBC resistant hood or cowl 1, preferably made of a butyl material, provided with a neck seal 2 and a shoulder apron 3. A window or visor 4 is sealingly fitted into the front of the cowl. The window illustrated is in one-piece but two separate windows may be provided. The cowl includes a forwardly extending snout portion 5 which is sealingly attached to the remainder of the cowl. This encloses a face mask 7 of normal type which covers the pilot's nose and mouth and makes a seal with the surrounding face area when drawn against it by retaining means in the form of straps 8. These straps are attached at one end to the face mask 7 through the cowl snout 5 by air tight connections 9 and at the other end to a bar 10 which releasably engages in a fitting 11 on the pilot's helmet 12. The helmet is retained on the pilot's head by a chin strap 13. It will be appreciated from the foregoing that the face mask 7 is a loose fit inside the snout 5 of the cowl 1 but it is nevertheless attached to it. The face mask also includes the usual radio microphone and it is connected to the breathable mixture in the manner to be described hereafter.

In a known respirator, the air/oxygen supply is fed to the front of the face mask through a supply pipe, the pilot inhaling the breathable mixture through the pipe which supplies the face mask directly. He exhales through a valve system which is concentrically arranged around the inlet pipe at the front of the mask.

In the respirator shown in Figure 1 the breathable mixture is supplied either from a portable blower (not shown) or from a plug-in port (not shown) mounted in the aircraft. The mixture is supplied at approximately 1 1/2"-2" water gauge pressure via hose 14 to the interior of the cowl. Unlike the prior art systems, the mixture is fed via inlet 15 into the cowl, the inlet having outlets 16 which exit above and at one side of the visor 4. The inlet 15 is normally a rubber tube attached to the inside of the cowl 1.

The face mask 7 is provided with at least one and preferably two inhalatory valves 17 (only one is shown for ease of illustration) and also includes an outlet duct 18 connected to an outlet assembly 19

which includes an upstream exhalatory valve 20 and a downstream exhalatory valve 21, there being a deadspace 22 between them. The valves 17, 20 and 21 are known flap valves which are normally closed.

In use, a breathable mixture is supplied to the interior of the cowl 1 past the visor 4 and, on inhalation by the pilot, is admitted to the interior of the face mask 7 through the inhalatory valve or valves 17. On exhalation, the valve or valves 17 are closed and expiratory valves 20, 21 open to exhaust the expirate to the exterior of the respirator. The dead space 22 is a valuable safety feature because it further reduces the possibility of the ingress of NBC agents into the interior of the cowl 1. It should be noted that although the respirator can be used successfully without an assisted pressurised supply, in the case of an emergency in a manner to be described hereafter, it is desirable to do so as it ensures that there is always a pressure in the cowl 1 so NBC agents cannot get in should the cowl get punctured or develop a small leak.

Should the pilot become separated from this portable pressurised air supply or from the one aboard his aircraft, he can still breathe filtered mixture and achieve visor demisting as the air drawn into the hose 14 on inhalation has already passed through an NBC filter mounted in known manner on his flying suit. Thus, the filtered air flows past the visor 4 to demist it and into and out of the face mask 7 as before.

Should the pilot be flying at an altitude up to 40,000 feet and his cabin become rapidly depressurised, for instance due to the canopy being damaged or the pilot having to eject from the aircraft, the rapid depressurisation will cause the cowl to inflate instantaneously. This would cause considerable discomfort to the pilot were it not for the fact that the pressure in the cowl can instantly be vented to atmosphere through the valves 17, 20 and 21 so on additional relief valve is needed.

The problem with the respirator just described is that it cannot perform at altitudes over 40,000 feet should the pilot's cabin become depressurised because immediately depressurisation occurs, the breathable mixture is pumped through the hose at the higher pressure which is needed to inflate the pilot's lungs. Accordingly, this pressure will constantly be higher than the operative values of the outlet valves so they will be constantly open and the respirator cannot work.

This problem is overcome by modifying the respirator of Figure 1 as shown in Figure 2. Essentially, it is the same as that of Figure 1 in that it comprises a cowl 1, a neck seal 2, a shoulder apron 3, a visor 4 sealingly fitted into the cowl, a snout 5 inside which a face mask 7 is mounted. Straps (not shown) attachable to the pilot's helmet 12 (see Figure 3) ensure that the face mask 7 makes a seal with the wearer's face. The inlet 15 has outlet openings 16 to direct the breathable mixture past the visor 4 for demisting. Preferably, the inlet is a tube which is stuck to the inside of the cowl along one or both sides thereof and over the top of the visor 4. The face mask 7 has one or more inhalatory valves 17 in it and an outlet duct 18 and outlet assembly 19. In Figures 1 and 2, this outlet assembly is shown on one side of the respirator for ease of illustration whereas it is, in fact, at the front thereof coaxial with the face mask 7 as shown correctly in Figure 3.

In order to cope with being able to satisfactorily supply a high pressure breathable mixture to the interior of the cowl, the inlet system has to be modified as does the expiratory valving system. Also, a hood relief valve 30 has to be fitted to the cowl.

The inlet supply is modified so that it includes a hood inlet valve 31 which, in the illustrated embodiment, is an aneroid valve with bellows 32 which are sensitive to substantial changes in external pressure. Thus, should the pilot's cabin depressurise, the bellows 32 will sense the change and expand against the action of a spring (not shown) which normally keeps the valve open, thereby closing sealing member 33 onto its seat 34 to make a seal therewith. The sealing member 35 has a calibrated hole in it (not shown) to permit limited flow through it so that a limited flow of breathable mixture continues to be supplied to the visor for demisting purposes when the valve 31 is closed by the bellows 32.

The sealing member 33 is connected by rod 35 to knob 36 which can be manually depressed by the pilot during a test procedure to ensure that the valve is working properly.

A small bore duct 37 which is of a lesser inside diameter than the inlet 15 connects the inlet 14 to the face mask 7 via a normally closed secondary inlet valve 38. A balance pipe 39 joins the small bore duct 37 to a sealed chamber 41 in a compensating valve whose sealing member 40 is connected to a diaphragm 42. Thus, movement of the diaphragm causes the sealing member 40 to move against its seat to make a seal therewith. The sealing member 40 is however normally kept against its seat by means of a spring (not shown) acting between it and the diaphragm 42. The outlet assembly 19 has an expiratory valve 21 in it and a dead space 22 as with the Figure 1 embodiment.

The operation of the respirator is as follows : In normal use, the breathable mixture is supplied via hose 14, either from a portable blower (not shown) or from a plug-in port on the aircraft at a pressure of 1 1/2"-2" water gauge as before. The hood inlet valve 31 is open so substantially all of the supply

of the breathable mixture is fed to the inlet 15 and passes into the interior of the cowl 1 via outlets 16 which direct it past the visor 4 to demist it. Because the duct 37 is of a smaller bore than the inlet 15, the breathable mixture tends to follow the line of least resistance and flow into the cowl through the inlet 15 rather than via secondary inlet valve 38. However, even if a small proportion of the supplied mixture does reach the face mask 7 by this route, it only enhances the breathing process so it is not detrimental. The pilot breathes in the mixture supplied to the cowl via inhalatory valve or valves 17 and exhales via the valves 40 and 21 as before.

If the pilot's cabin becomes depressurised however, and he is flying at over 40,000 feet, he needs to be supplied with a breathable mixture at a much higher pressure of up to 17" water gauge and he needs to be supplied with this almost instantly. On depressurisation, the on-board regulator in the aircraft senses that a higher pressure is needed and as a result the breathable mixture is supplied at the appropriate pressure for the altitude at which the aircraft is flying.

At the same time, the hood inlet valve closes due to the bellows 32 expanding. Thus, the path of the breathable mixture, now supplied at high pressure, to the inlet 15 is blocked so it flows along the small bore duct 37 via inhalatory valve 38 and into the face mask 7 so the pilot can continue to breathe normally.

The compensatory hole in the hood inlet sealing member 33 allows a limited flow of breathable mixture to reach the inlet 15 so a flow of mixture continues to be supplied to the visor 4 to demist it. Were it not for the balance pipe 39 connecting the duct 37 with the chamber 41, this increased pressure flow would lift the sealing member 40 from its seat. However, it will be appreciated that this pipe 39 effectively ensures that whatever pressure is applied to the upstream side of secondary inhalatory valve 38 is also applied to the downstream side of the sealing member 40 of the compensatory valve, thereby neutralising the effect of the increased pressure on the valve member 40 and preventing it from opening. When the pilot breathes, however, and exhales, the pressure in the mask 7 rises above the tugger pressure of the valve member 40 maintained by the action of a spring (not shown) so the valve can open as before on exhalation in the usual way. By this means, the expiratory valving system will continue to work regardless of the pressure of the supplied breathable mixture.

On decompression, the cowl 1 will inflate as before but the pressure cannot be relieved via the expiratory valves 40 and 21 as with the Figure 1 embodiment, so hood relief valve 30 has to be provided. This immediately opens on decompression to vent the pressure differential in the cowl to atmosphere. It then closes again and is no longer required as it has done its job. Once the aircraft or the pilot reaches an altitude below 40,000 feet, the valve 31 will open once again, and the breathable mixture will be supplied at a more normal 1 1/2"-2" water gauge pressure so normal breathing can be resumed.

In the event that the pilot is not connected to either a portable blower or the aircraft's pressure supply system, he can still breathe filtered air normally and achieve demisting as the air inhaled will pass via the inlet 15, past the visor to demist it and into the face mask 7.

Should the pilot land in water, the cowl can include some means of piercing it located above the water line on the cowl so that rather than inhale water through the hose 14, he can breathe through the hole in the cowl. Conveniently, this can be a valve (not shown) provided on the side of the cowl but communicating with the inlet 15 which can be manually released by the pilot pulling a release pin. A water sensitive valve or other suitable means could be used. Having gained access to the outside atmosphere via the valve, the pilot can then breathe normally as air will be entering the cowl through the hole or valve located above the water line.

Preferably, the inhalatory valve or valves 17 are 25mm in diameter whereas the secondary inhalatory valve is 14mm in diameter. This gives a sufficient valve bias to ensure that, in normal breathing at a supply pressure of 1 1/2"-2" water gauge, the major part of the flow passes through the inlet 15 into the cowl, rather than via secondary inlet valve 39. Provided some differential is provided, the valve diameter dimensions are not critical.

It should be noted that although the outlet assembly with its valve system is shown in Figures 1 and 2 as being on one side of the respirator, this has been done for ease of illustration and in fact, the outlet assembly 19 is provided on the front of the cowl 1 in the middle of the face mask 7.

Claims

1. A respirator comprising a cowl impervious to NBC agents shaped to enclose a wearer's head and neck, the cowl having a transparent viewing window (4) therein and an inlet (14) for admitting a breathable mixture to the interior of the cowl, a face mask (7) inside the cowl which is shaped to fit over a wearer's nose and mouth and make a seal with the wearer's face when held in position thereon by retaining means, characterised in that the mask has at least one normally closed inhalatory valve (17)

therein, and an outlet (18) therefrom leading to the exterior of the cowl incorporating at least one normally closed expiratory valve (20, 21) therein, the arrangement being such that, in use, at least the major proportion of the breathable mixture is supplied to the interior of the cowl past the interior of the window to de-mist it, said breathable mixture in the cowl then being admitted to the interior of the face mask through the or each inhalatory valve (17) only on inhalation by the wearer and exhausted therefrom through the or each expiratory valve (20) only on exhalation by the wearer, said exhalation by the wearer opening the or each normally closed expiratory valve (20, 21) in the outlet.

2. A respirator as claimed in claim 1, characterised in that the inlet (14) is constructed to direct all the supplied mixture to the interior of the cowl.

3. A respirator as claimed in claim 1 or claim 2, characterized in that said inlet (14) has one or more outlet openings (16) adjacent the window to direct a flow of said supplied breathable mixture over the interior of the window for demisting purposes.

4. A respirator as claimed in any one of claims 1-3 characterised in that two expiratory valves (20, 21) are provided in the outlet to the cowl with a dead space therebetween.

5. A respirator as claimed in claim 4 characterised in that the expiratory valve (21) sealing the deadspace from the exterior of the cowl is a flap valve.

6. A respirator as claimed in any one of the preceding claims characterised by two of said inhalatory valves (17) being provided on the face mask located, in use, on either side of the wearer's nose.

7. A respirator as claimed in any one of claims 4 to 6 characterised in that the exhalatory valve (20) upstream of the deadspace is a flap valve.

8. A respirator as claimed in any one of claims 4 to 6 characterised in that the major portion of the supplied breathable mixture is fed to the interior of the cowl past the window, the inlet also having a smaller bore duct (37) leading from it which communicates with the interior of the face mask via a secondary inlet with a normally closed secondary inhalatory valve (38) therein.

9. A respirator as claimed in claim 8 wherein the secondary inhalatory valve (38) is smaller than the or each inhalatory valves in the face mask whereby, in normal use, the or each of said inhalatory valves (17) opens in preference to said secondary inhalatory valve (21) on inhalation by water.

10. A respirator as claimed in claim 8 or claim 9 characterised in that the inlet is closed downstream of the smaller bore duct by a hood inlet valve (31) responsive to changes in external pressure or increases in delivery pressure, said valve being normally open to permit flow of the breathable mixture to the interior of the cowl, but being operable to close on sensing a substantial drop in the external pressure or a rise in delivery pressure.

11. A respirator as claimed in claim 10 characterised in that the hood inlet valve (31) includes a sealing member (33) which seals against a seat (34), said sealing member having a calibrated hole therein to permit limited flow therethrough, when the valve is closed, to supply the window in the cowl with a limited flow of said breathable mixture sufficient for demisting purposes.

12. A respirator as claimed in claim 11 characterised in that the expiratory valve upstream of the deadspace is a compensated valve which comprises a sealing member (40) which is normally biased by means to seal against a seat, said sealing member also being connected to a diaphragm (42) movable thereby into sealing engagement with the seat, the diaphragm forming part of a sealed chamber, the interior of which is connected by a by-pass duct (39) to said smaller bore inlet duct (37), whereby, in use, on inhalation, the secondary inlet valve opens to admit said breathable mixture to the interior of the mask, there being no pressure differential across the expiratory valve due to the bypass duct connecting the interior of the sealed chamber with the secondary inlet duct so the expiratory valve remains closed under the action of its biasing means, said secondary inlet valve being closed on exhalation and the increase in pressure in the face mask generated thereby overcoming the action of the expiratory valve biasing means and causing it to open.

13. A respirator as claimed in any one of claims 8 to 12 characterised in that the cowl includes a separate relief valve (30) operable to vent the cowl to atmosphere should a substantial pressure differential arise between the interior and the exterior of the cowl.

14. A respirator as claimed in any one of claims 11 to 13 characterised in that the sealing member (33) of the hood inlet valve (31) may be manually closable for test purposes on depression of a plunger (35) connected to its sealing member (33).

15. A respirator as claimed in any one of claims 10 to 14 characterised in that the hood inlet valve (31) is an aneroid valve actuated by pressure sensitive bellows.

16. A respirator as claimed in any one of claims 10 to 14 characterised in that the hood inlet valve (31) is a diaphragm valve actuated by delivery pressure.

17. A respirator as claimed in any one of claims 8 to 15 characterised in that the cowl is provided with means whereby the interior of the

cowl can be placed in communication with its exterior at normal atmospheric pressure.

18. A respirator as claimed in claim 17 characterised in that said means is a valve which includes a manually removable pin which, when removed, places the sealed interior of the cowl in communication with the exterior thereof.

19. A respirator as claimed in claim 18 characterised in that said valve is fitted to the cowl in the inlet thereto between the hood inlet valve and the window.

20. A respirator as claimed in claim 19 characterised in that the face mask retaining means are straps provided on the exterior of the cowl and attached to the face mask, each of said straps having a releasable connector at its other end for attachment to the helmet of a wearer.

RESPIRATOR

This invention relates to a respirator and more particularly, but not exclusively, to a respirator for protecting aircrew against nuclear, biological or chemical agents (NBC).

In the event of a nuclear, biological or chemical attack, groundstaff and particularly aircrew must be protected against NBC agents. The pilot in particular must be able to reach his aircraft breathing clean filtered air. Once inside, he can then either connect his face breathing mask to the on-board oxygen supply in the aircraft or he can continue to use his portable blower assisted system.

For such respirators to be acceptable for aircrew, they must not only be capable of fulfilling their function at ground level but they must also enable the pilot to be able to continue to breathe over the range of cabin altitudes when he is flying . If this is under 40,000 feet, then he will normally be breathing a mixture supplied at a low pressure of about 1 1/2"-2" water gauge and no increase in that supply pressure is needed for him to survive a decompression. However, if he is flying at an altitude over 40,000 feet, then his breathable mixture may have to be supplied at a much greater pressure dependant on the altitude he is at. In some cases this pressure could be as much as 17" water gauge.

Another serious problem with known respirators is that complicated means have to be provided to prevent the visor misting up. This has been done in the past by diverting some of the oxygen supplied directly into the face mask and directing it against the visor. The main problem with this system is that it uses valuable oxygen which could otherwise be breathed to de-mist the visor and thus is undesirable bearing in mind that the aircraft has a limited supply of oxygen on board. Another problem with this prior art system is that it constantly blows air onto the visor which makes it very difficult for the pilot to carry out a face mask seal test as air is blowing in his face all the time from the top of the face mask, which is exactly the place where he normally feels air escaping if the face mask is not sealing properly.

It is an object of the invention, therefore, to provide a respirator which functions both at ground level and at altitude in the event and which also prevents the viewing window from misting up.

According to the invention, there is provided a respirator comprising a cowl impervious to NBC agents shaped to enclose a wearer's head and neck, the cowl having a transparent viewing window therein and an inlet for admitting a breathable mixture to the interior of the cowl, said inlet being constructed to direct all or the major proportion of said supplied breathable mixture to the interior of the cowl so that it flows past the window, a face mask inside the cowl which is shaped to fit over a wearer's nose and mouth and make a seal with the wearer's face when held in position thereon by retaining means, the mask having at least one normally closed inhalatory valve therein, and an outlet therefrom leading to the exterior of the cowl incorporating at least one normally closed expiratory valve therein, the arrangement being such that, in use, at least the major proportion of the breathable mixture is supplied to the interior of the cowl past the interior of the window to de-mist it, said breathable mixture in the cowl then being admitted to the interior of the face mask through the or each inhalatory valve only on inhalation by the wearer and exhausted therefrom through the or each expiratory valve only on exhalation by the wearer, said exhalation by the wearer opening the or each normally closed expiratory valve in the outlet.

Preferably, the inlet is constructed to direct all the supplied mixture to the interior of the cowl, the inlet having one or more outlet openings adjacent the window to direct a flow of said supplied breathable mixture over the interior of the window for demisting purposes.

In order to provide added protection against the ingress of NBC agents to the interior of the cowl, the outlet preferably has two expiratory valves in it, a dead space being provided between the two valves. Conveniently, one or both of said expiratory valves is a flap valve but other types of valve could be used.

If the respirator is to be used for high altitude flying above 40,000 feet, then it requires some modification to enable it to function in the event of cabin depressurisation. Accordingly, the invention further provides a respirator whose inlet is constructed to direct the major portion of the supplied breathable mixture fed to the interior of the cowl past the window, the inlet also having a smaller bore duct leading from it which communicates with the interior of the face mask via a secondary inlet with a normally closed secondary inhalatory valve therein.

Preferably, the secondary inhalatory valve is smaller than the or each inhalatory valve in the face mask whereby, in normal use, the or each of said inhalatory valves opens in preference to said secondary inhalatory valve on inhalation by the wearer.

Conveniently, the inlet is closed downstream of the smaller bore duct by a hood inlet valve responsive to changes in external pressure or increases in delivery pressure, said valve being normally open